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G2J JBSS1

(56) Documents cited
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GB 2071924 A GB 1594336 A GB 1461362 A
GB 1440688 A US 4844577 A

(58) Field of search
UK CL (Edition K) G2J JBSS1 JGEE
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(54) Piezoelectric actuator to [un]block or redirect light path

(57) An optical switch for use as a shutter for intercepting or passing light signals, such as light beams, includes a piezoelectric actuator 2 optionally attached at one end thereof to a base plate 1 and at its other end to an optical shielding interceptor means 5 for blocking or unblocking a beam of light in a defined light path 11. A mirror 9 may be installed close to where the piezoelectric actuator 2 is attached to the base plate 1 to redirect the light beams. The piezoelectric actuator 2 is selectively coupled to a source of energy 8 so that light signals 11 are correspondingly intercepted or unblocked by the movement of the interceptor means 5 due to movement of the piezoelectric actuator 2. The light signals, re-directed by the mirror 9 may be detected by an optical detector 12.

FIG. 1

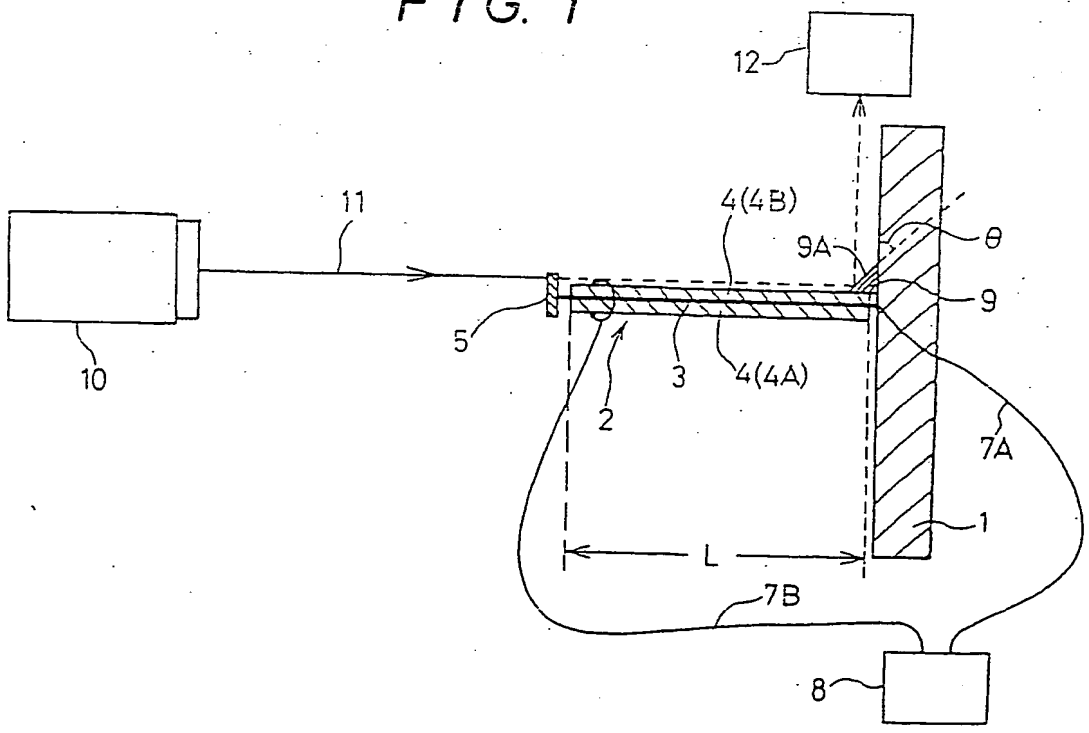


FIG. 1

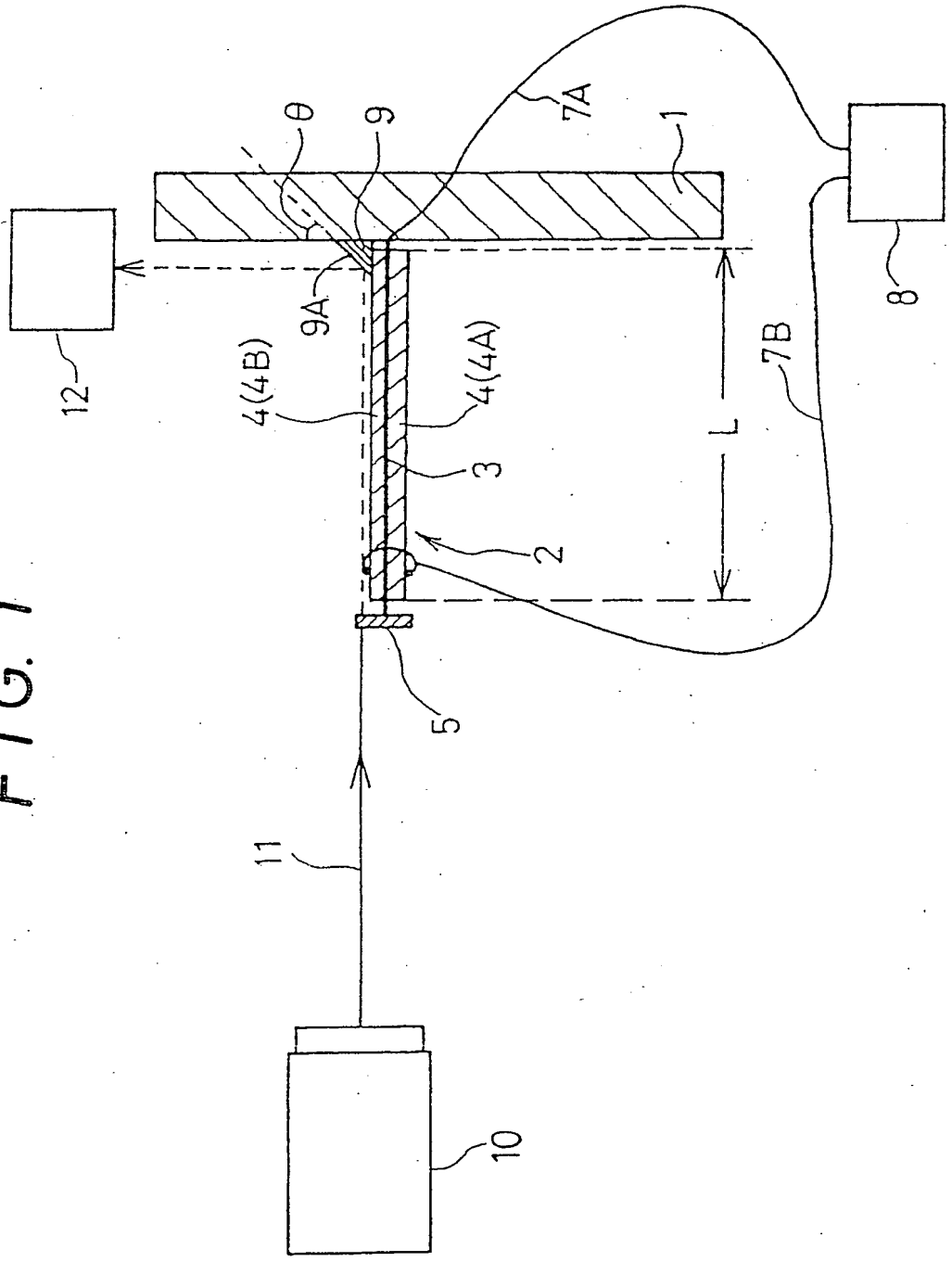


FIG. 2

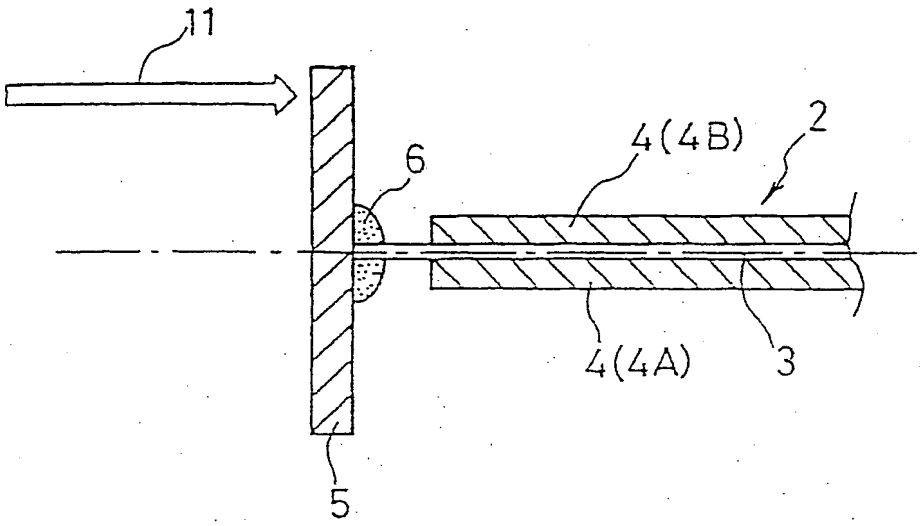


FIG. 3

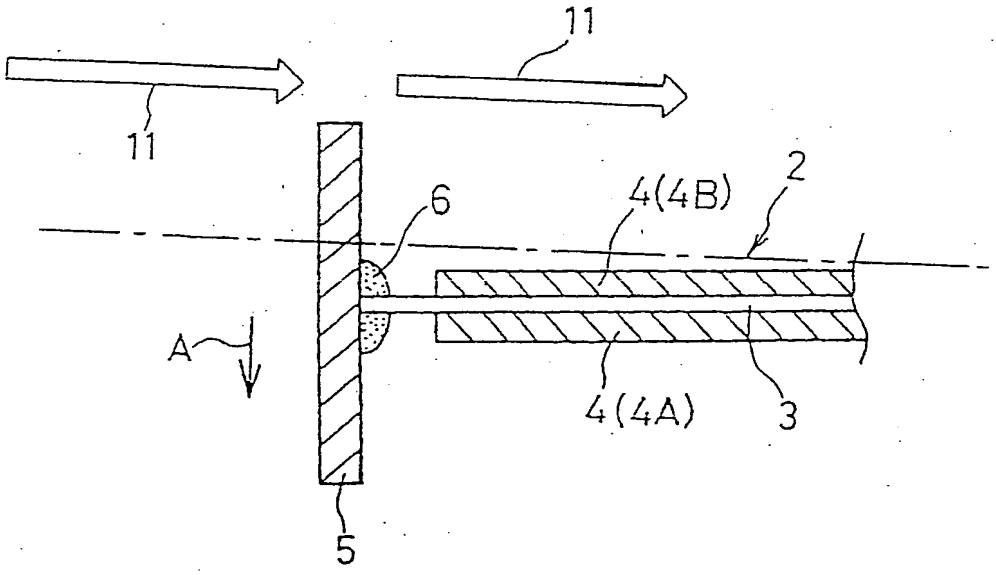


FIG. 4

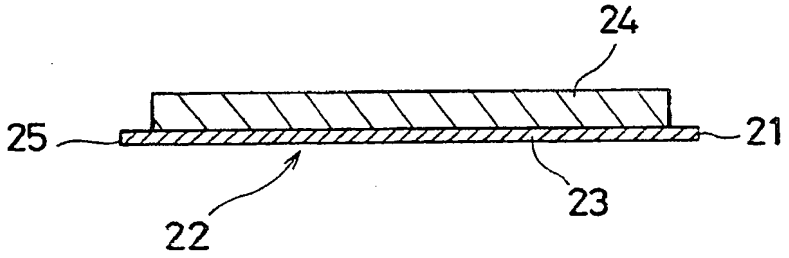
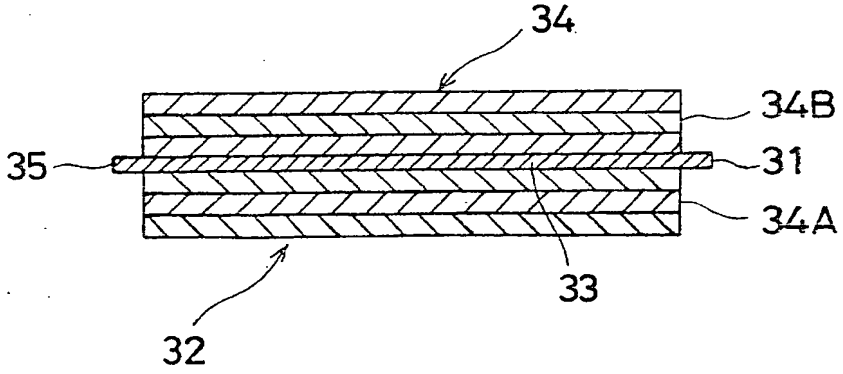


FIG. 5



AN OPTICAL SWITCH

BACKGROUND OF THE INVENTION

I. Field of the Invention

This invention relates to an optical switch.

More particularly, this invention is concerned with an optical switch which is mainly used as a shutter for intercepting or passing light signals and is characterized by having a small size and a light weight, and by having a shutter operated by a piezoelectric actuator. A mirror for changing the direction of the light signals can also be incorporated.

II. Description of the Prior Art

Shutters for selectively intercepting or passing light signals are typically classified into mechanical shutters and non-mechanical shutters.

Mechanical shutters are operated by mechanical methods (such as rotating mirrors, lenses or prisms in the shutters) or by changing the connection point between fiber optic cables therein.

Non-mechanical shutters are operated by non-mechanical methods, e.g. by utilizing acousticoptical or electrooptical effects.

Known mechanical shutters are quite cumbersome, heavy, and require a large quantity of electric power because electric motors are used in their driving systems to rotate or move the optical elements thereof. For example, a motor can be used for rotating a polygon mirror used to intercept light signals; preventative measures must be taken against vibratory and electromagnetic noises of the motors.

Non-mechanical shutters also present problems. Electrooptically operating shutters using PLZT (lanthanum-doped lead zirconate-lead titanate), etc are often unsuitable in that the intensity of the output light signals passed through the shutters is very much lower than that of input light signals reaching the shutters, because the polarizers and optical detectors used in the shutters absorb the input light signals.

Shutters utilizing liquid crystals are also often unsuitable in that S/N (signal to noise) ratios are diminished because the liquid crystals absorb incident light signals. The liquid crystals may also become damaged by intensive light signals.

Shutters operated by CCD (charge-coupled device or electrocharge combination device) are often unsuitable in the light signals can not directly pass through the shutters. In such devices the light signal is converted to electric signals in the shutters.

SUMMARY OF THE INVENTION

This invention sets out to provide an optical switch which is free of the above problems and is of small size and light weight. It utilizes a shutter operated by a piezoelectric actuator and usually also a mirror for changing the direction of the light beam.

The invention consists in an optical switch in which an assembly comprising a piezoelectric actuator is located adjacent or intercepting a defined light path, the piezoelectric actuator being such that a voltage selectively applied thereto causes a correspondingly selective movement of the assembly adequate to block, unblock or redirect the light path.

Preferably, the invention provides such a switch in which the said assembly comprises an elongate piezoelectric actuator having an inner end thereof attached to a base plate; interceptor means for selective positioning into the light path, attached to an outer end of said piezoelectric actuator; and a

mirror installed in the light path to alter the direction thereof; the switch further comprising means for applying a voltage to said piezoelectric actuator.

The mirror may be located adjacent the point of attachment of the actuator inner end to the base plate.

The inventive optical switch selectively intercepts or passes light signals, such as light beams, in response to switch-on or switch-off condition as explained hereinafter.

When a voltage is not applied to the piezoelectric actuator, i.e. in a switch-off condition of the piezoelectric actuator, light beams from an optical source located for instance on a side opposite to the side of the base plate are intercepted by the interceptor means attached to the outer end of the piezoelectric actuator and are not transmitted.

When a voltage is applied to the piezoelectric actuator, i.e. in its switch-on condition, the interceptor means attached to the outer end of the peizoelectric actuator is moved downwardly to permit the beam to pass over the interceptor means. When the beam passes over the object, it typically thereafter impinges onto the mirror (installed on the base plate or on the piezoelectric actuator) and is redirected by the mirror

surface to for example an optical detector located at a suitable position.

The piezoelectric actuator used can be a bimorph-type, unimorph-type or multimorph-type.

The material used for the interceptor means in this invention can be any material which can obstruct a light beam but has no effect on the operation of the piezoelectric actuator.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be further described with reference to the accompanying drawings, in which:-

Fig. 1 is a schematic sectional view of an embodiment of optical switch in accordance with this invention using a bimorph-type piezoelectric actuator;

Fig.2 is an enlarged partially sectional view depicting an off-condition of the optical switch shown in Fig. 1;

Fig.3 is an enlarged partially sectional view depicting an on-condition of the optical switch shown in Fig.1;

Fig.4 is a partial schematic view another embodiment using a unimorph-type piezoelectric actuator; and

Fig.5 shows part of another embodiment of the invention using a multi-morph-type piezoelectric actuator.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In Figure 1, a bimorph-type piezoelectric actuator 2 comprises a shim plate 3 sandwiched between two piezoelectric elements 4A and 4B adhered to upper and lower surfaces of the shim plate 3, for use as the piezoelectric actuator of this invention. The spontaneous polarization of each piezoelectric element points in a downward direction.

The inner end of the piezoelectric actuator, at the shim plate 3, is connected to the brass base plate 1 at 90° by soldering. The other end of the shim plate 3 is connected to an optical shield 5, as an interceptor means. This optical shield may alternatively be connected with one or both of the piezoelectric elements 4A and 4B.

Therefore, when a voltage is applied to the bimorph-type piezoelectric actuator 2, the outer end of the bimorph-type piezoelectric actuator 2 moves

downwardly in a direction towards the bottom of Fig.1 by the shrinkage of shortening of the length dimension L of the piezoelectric element 4A and the extension or increase in the length dimension of the piezoelectric element 4B. This results in a movement from the Fig.2 to the Fig.3 position with the piezoelectric ends at interceptor shield 5 pointing downwardly as best seen in Fig. 3.

The outer end of the shim plate 3 is adhered to a central position of the interceptor plate 5, made e.g. of aluminium, by an epoxy resin adhesive agent 6, see Figs. 2 and 3.

Shim plate 3 at its inner end is electrically connected to a DC power source 8 by lead wire 7A so that it becomes the ground for the DC power source, and the individual piezoelectric element 4A and 4B are electrically connected to DC power source 8 by lead wire 7B so that their upper surfaces become positive sides electrically.

A mirror 9 is attached to the brass base plate 1 in such a location as to reflect a light beam 11 which emerges from a He-Ne laser source 10 and passes over optical interceptor shield 5. It re-directs the beam towards optical detector 12 when the optical switch is in its switch-on condition.

The mirror, which is typically attached to brass base plate 1 close to the place where the mirror end of the shim plate 3 is soldered has a mirror surface 9A at an angle of 45°, to the brass base plate 1.

When a voltage is not applied to the optical switch by the power source 8, i.e. when the switch is in its switch-off condition, the light beam 11 is intercepted by the upper part of the aluminum plate 5, as shown in Fig. 2.

When a voltage is applied to the optical switch, i.e. in a switch-on condition, and the aluminum plate 5 attached to the other end of the shim plate 3 of the piezoelectric actuator 2 is moved downardly the light beam can pass over the aluminum plate 5 and impinge onto the mirror 9, to be redirected by the mirror surface 9A for detection by the optical detector 12, as shown in Fig.3.

A mirror having an angle of less than 45° may alternatively be used to obtain a smaller reflection angle of the light beam.

Mirror 12 may also be installed on the bimorph-type piezoelectric actuator. In this case the effective angle of the mirror to the beam may be altered as the

piezoelectric actuator 2 operates.

The amount of movement of the outer end of the piezoelectric actuator 2 is in proportion to its length. A longer piezoelectric actuator can control a larger diameter beam, or be used at lower voltages. Conversely, a shorter piezoelectric actuator may be used for a smaller diameter light beam.

TEST 1

Bimorph-type piezoelectric actuator 2 with the piezoelectric element 4 of approximately 30mm in length was used.

When a DC voltage of 200 volts was applied to this bimorph-type piezoelectric actuator 2 the outer end of the shim plate 3 was pulled down by an amount of 600 to 700 μm.

The aluminum plate 5 measured 2.2 mm x 2.2 mm. It was used to intercept a light beam 11 of a beam dimeter 400 to 500 μm and unblocked such a beam when the voltage was applied.

The invention can also be carried out using a unimorph piezoelectric actuator in the optical switch. Fig 4 shows a unimorph-type actuator 22 which comprises

a shim plate 23 with a single piezoelectric plate 24 adhered at one surface only of shim plate 23. The inner end 21 of the shim plate 23 is soldered to brass base plate 1 of Fig. 1 as before, and the outer end 25 is connected to aluminum plate 5 (see Fig.1) by an epoxy, adhesive as also shown in Figs. 2 and 3.

Fig.5 shows the use of a multimorph-type piezoelectric actuator 32. Shim plate 33 has an inner end 31 soldered to brass base plate as in Fig. 1 and the other end 35 adhered to aluminum plate 5.

The piezoelectric actuator 32 comprises two groups of piezoelectric plates 34, with one group or set of such plates (34A) positioned to one side of shim plate 33 and the other set of such plates (34B) positioned to the other side of the shim plate 33.

The embodiments shown in Figs 4 and 5 are generally similarly to those of Figs. 1 to 3. In one mode of the optical switch (i.e. when energized) the aluminum plate optical shield 5 is in the Fig. 3 position to permit light beams to pass.

While there has been shown what is considered to be the preferred embodiment of the invention, various changes and modification may be made within the scope of the appended claims.

CLAIMS:

1. An optical switch in which an assembly comprising a piezoelectric actuator is located adjacent or intercepting a defined light path, the piezoelectric actuator being such that a voltage selectively applied thereto causes a correspondingly selective movement of the assembly adequate to block, unblock or redirect the light path.

2. The optical switch as claimed in claim 1 in which the said assembly comprises an elongate piezoelectric actuator having an inner end thereof attached to a base plate; interceptor means for selective positioning into the light path, attached to an outer end of said piezoelectric actuator; and a mirror installed in the light path to alter the direction thereof; the switch further comprising means for applying a voltage to said piezoelectric actuator.

3. The optical switch as claimed in claim 2, in which the mirror is located adjacent the point of attachment of the actuator inner end to the base plate.

4. The optical switch as claimed in any one preceding claim wherein piezoelectric actuator includes a shim plate and at least one piezoelectric element.

5. The optical switch as claimed in claim 4, wherein said at least one piezoelectric element is connected to said interceptor means.

6. The optical switch as claimed in claim 4, wherein said base plate is attached to an inner end of said shim plate by soldering.

7. The optical switch as claimed in claim 4, wherein said interceptor means is attached to an outer end of said shim plate with a suitable adhesive.

8. The optical switch as claimed in any one preceding claim, wherein said piezoelectric actuator is a uniimorph type piezoelectric actuator.

9. The optical switch as claimed in claim 8, wherein said piezoelectric actuator includes a shim plate having an inner end connected to said base plate and an outer end connected with said object, and a piezoelectric element connected at one side only of said shim plate.

10. The optical switch as claimed in any one of claims 1 to 7, wherein said piezoelectric actuator is a bimorph type piezoelectric actuator.

11. The optical switch as claimed in claim 10, wherein said piezoelectric actuator includes a pair of spaced

piezoelectric elements having a shim plate therebetween.

12. The optical switch as claimed in any one of claims 1 to 7, wherein said piezoelectric actuator is a multimorph type piezoelectric actuator.

13. The optical switch as claimed in claim 12, wherein said piezoelectric actuator includes a pair of groups of piezoelectric plates and a shim plate sandwiched between the groups of the pair.

14. The optical switch as claimed in any one preceding claim wherein said interceptor means is an aluminum plate.

15. The optical switch as claimed in any one preceding claim and further comprising an optical detector for receiving light transmitted along the light path when not intercepted by the interceptor means.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

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Application number

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Relevant Technical fields

(i) UK Cl (Edition K) G2J(JBSS1,JGEE)

(ii) Int CL (Edition 5) G02B

Search Examiner

MR C J ROSS

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search

10 JUNE 1992

Documents considered relevant following a search in respect of claims 1-15

Category (see over)	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2207527 A	(GEC) see especially page 2 line 8 on	1 at least
X	GB 2196754 A	(OXLEY)	1 at least
X	GB 2176023 A	(GEC) see especially page 1 line 107 on	1 at least
X	GB 2071924 A	(LAOR)	1 at least
X	GB 1594336	(PLESSEY) see especially the figure	1 at least
X	GB 1461362	(BAC) see especially piezoelectric transducer 7	1 at least
X	GB 1440688	(SIEMENS)	1 at least
X	US 4844577	(SPORTSOFT) see especially Figures 1,6	1 at least

Category	Identity of document and relevant passages	Relevant to claim(s)

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